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Installation of Solar Energy Technologies and Sustainable Environmental Performance in the Energy Sector of Pakistan: An Empirical Analysis Based on the Moderating Role of Government Policy

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ABSTRACT

The primary goal of this study is to assess whether the adoption of solar energy, along with the government's role, impacts sustainable environment performance in power sector organizations in Pakistan. To better understand the relationships among these concepts, a quantitative study was conducted. Data were collected from 307 employees working in the power sector in Pakistan. Using structural SPSS software for analysis. The study results show that adopting solar energy improves sustainable performance. Furthermore, the findings demonstrate that government policies have a positive moderating effect on the adoption of solar energy and sustainable environment performance. These study results may provide organizational leaders with guidance for implementing productive work environments by leveraging valuable solar energy resources to achieve sustainable performance standards, while also fostering employee participation in the strategic process of transforming systems to meet long-term objectives.

Introduction

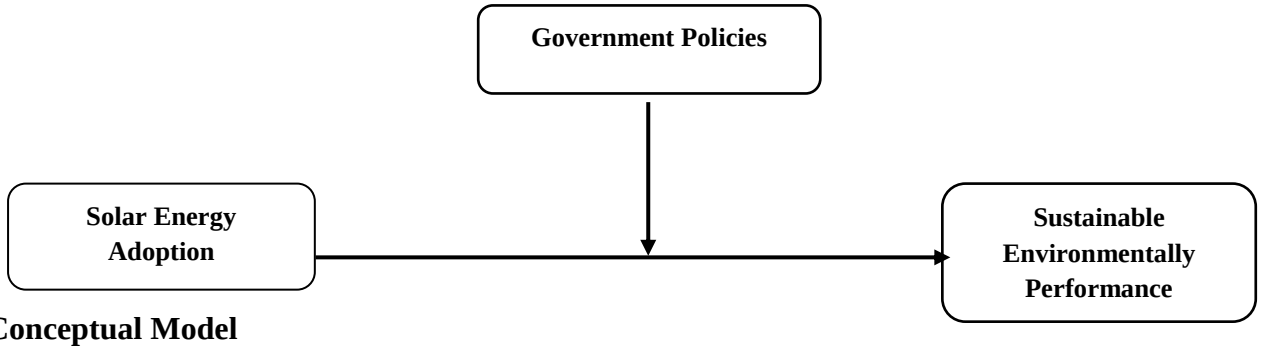
The solar energy adoption refers to the utilization and integration of the sustainable energy sources like as solar power in place of a non-renewable resource such as fossil fuel and green innovation is comprising the all kinds of innovations which contribute to the create the vital key products, the services, or the procedures to reduce the hazard, the impact, and the weakening to the environment at the same stage which enables to optimizes the prompt use of natural resources of energy sector. In reality, renewable energy, with its means, has become more important to policy and decision-

makers (Chu & Meisen et al., 2011). These kinds of innovations can play a critical role in the current situation because they can channel the appropriate use of natural resources to improve them and promote human well-being. Moreover, these new forms of creation and innovation, along with the incorporation of changes in products and production procedures, could contribute to sustainable development and environmental protection. Solar energy also sustains life on Earth. It is becoming a widely accepted general term that solar energy should be transformed and used as a substitute for fossil fuels. It is assumed to be an environmentally friendly energy source due to its direct solar energy (Jager et al. 2014). The most promising source of future energy for developing nations is solar energy. Additionally, solar energy creates more jobs, lowers pollution, and benefits the environment (Kabir et al., 2018). With a focus on prioritizing the matter of adopting renewable energy, sustainability is a key lead for using as a compensation for the scarcity of conventional sources due to their participation in improvement related to the environment by reduction in costs, which provides the efficient impacts by adopting renewable energy sources for the sustainable development (Said et al.,2022). Although the continuous use of renewable energy technologies can reduce carbon dioxide emissions, it can also raise public awareness of the impacts of climate change (Kumar et al., 2020). The statistical evidence indicates that investments in renewable energy sources enhance environmental protection and contribute to energy savings (Ganda et al., 2019). One of the most well-known energy sources in the world is solar energy, as advancements in solar technology have enabled affordable electricity (Honrubia-Escribano et al., 2018). Solar photovoltaic (PV) is emerging as a desirable alternative for producing power. The most promising source of future energy for developing nations is solar energy. Additionally, solar energy creates more jobs, lowers pollution, and benefits the environment (Kabir et al., 2018). Half of Palestine's renewable energy comes from solar power, with the other half coming from biomass and other sources (Numan et al., 2026). The most popular technology for achieving sustainable, future-oriented investments is solar photovoltaics. Furthermore, because Palestine receives one of the highest levels of solar radiation, solar energy has helped alleviate energy poverty in the country and has contributed to economic development that improves the population's quality of life (Hilal and Nassar, 2018). With the addition of this sort of renewable energy, which can be preferred over others because it does not produce solid materials, liquid materials, and waste between operations, despite some dust and little pollutants that decrease the effectiveness of Photovoltaic panels, and some water is necessary for continuous cleaning of panels from time to time to work in good condition. For this reason, in the minds of the public, the change in climate is becoming a common environmental problem in the current age, and by utilizing solar energy, the production of electricity can help decrease the impact of greenhouse gas emissions on the environment. In light of these two occurrences, the government should lift the necessary precautions and develop policies to promote renewable energy generation and environmental protection (Fayaz et al., 2022). With the addition of a developing country, the adoption of renewable energy technologies has played a significant role in increasing employment options for the public by improving social sustainability and promoting economic growth (Arroyo and Miguel et al., 2020). Renewable energy adoption is also popular for its role in environmental sustainability. It also reduces pollution and improves network efficiency (Franzitta et al., 2013). Although the continuous use of renewable energy technologies can reduce carbon dioxide emissions, it can also raise public awareness of the impacts of climate change (Kumar et al., 2020). A nation's government can significantly influence the adoption of alternative energy sources through the implementation of financial subsidies, the provision of essential information, marketing policies, technical assistance, consultation services, and mentoring and strategy formulation for its organizations (Kata et al., 2022). Yang and Danwana et al. (2021) assessed that the government is accountable for formulating various policies to promote the adoption of energy sources that are renewable, which include the feed-in tariffs and the net metering policies, along with energy accounting procedures, which are deemed efficient strategies to encourage the utilization of photovoltaic (PV) systems.

Cunningham and Eck et al. (2021) note that governmental policies encompassed legislation, loan allocations, certain grants, and programs aimed at energy efficiency, alongside sustained research on the adoption of RES. Nevertheless, the Egyptian government enabled investment opportunities in renewable energy projects, yielding significant social and economic advantages through tax exemptions and rebates. The Jordanian government facilitated the adoption of RES through competitive bidding, feed-in tariffs, and foreign grants & loan assistance (Sandri et al., 2020). As discussed above, the following hypotheses are formulated.

Hypothesis H1: The solar energy adoption has a positive impact on sustainable environment performance.

Hypothesis H2: The government policies have a positive moderator role in the adoption of solar energy and sustainable environment performance.



Conceptual Model

Methodology

This study shows that the adoption of solar energy has a positive impact on sustainable environmental performance in the Pakistan's power sector. The empirical study-based moderator role of government policies and sustainable environment performance. This research uses methodologies and analytical tools that have been developed over time, based on previous research using multidisciplinary articles written by F. Saddique & N Mushtaq et al. (2021 to 2026), in which survey instruments were shared with the power sector organization of Pakistan. A total of 400 surveys were initially sent; however, only 307 were completed and returned. Some methods used in research are adopted from the old studies which were done by the (N, Mushtaq & F, Saddique et al., 2020 to 2026)

Table 3.1: Detail of Variables, No. of Items, and Reference:

Variable	Items	Reference
Solar Energy Adoption	5	(El-Khozondar et al., 2018)
Government Policies	5	(Meidute et al., 2021)
Sustainable Environment Performance	4	(Saleh et al., 2023)

Table 3.2: Sample Distribution:

	Characters	F
Gender	Male Female Total	204 103 307
Ages	Less than 30	60

	31-45 46-55 Above 55	130 98 19
Qualification	Matric Inter Bachelor Master and above	30 45 130 102
Experience	Less than 5 Years From 6 to 10 Years From 11 to Above	60 145 102

Explanation: As shown in Table 3.2, the demographic details of this study sample are based on 307 respondents. The gender in the above table is male = 204 and female = 103. The age group is divided into three parts; the largest study group is 31 to 45, with 130 respondents. The qualification is divided into four parts; the largest group is bachelor's, with 130 respondents. The experience is divided into three parts; the highest part is between 6 and 10 years, with 145 respondents.

Table 3.3: Reliability Analysis:

Variable	Cronbach's Alpha
Solar Energy Adoption	0.85
Government Policies	0.86
Sustainable Environment Performance	0.81

Explanation: In Table 3.3, the Cronbach's alpha values are above 0.70, allowing further analysis.

Table 3.4: Correlation Analysis Table:

Variables	1	2
1. Adoption of Solar Energy	1	
2. Sustainable Environment Performance	0.331**	1
3. Government Policies	0.321**	0.398**

Note: P value < 0.05

Explanation: Table 3.4 presents the relationship between the adoption of solar energy and sustainable environmental performance, which is positive (p = 0.01; r = 0.331). Likewise, there is a positive correlation between solar energy adoption and government policies (p = .001; r = 0.321). Lastly, the relationship between sustainable environmental performance and Government Policies shows a positive correlation (p = .001; r = 0.398).

Regression Analysis

Model between Solar Energy Adoption and Sustainable Environment Performance

Variable	R^2	B	t	sig
Adoption of Solar Energy	0.189	0.379	8.99	0.000

Dependent Variable: Sustainable Environment Performance * p < 0.05.

Explanation: The results in Table 3.5.1 show the relationship between the adoption of solar energy and sustainable environmental performance. In addition, the ANOVA p-value is 0.05 or

lower. Based on the R-Square of 0.189, it can be observed that each unit increase in solar energy adoption results in approximately a 18.9% variance in sustainable environment performance. Additionally, the p-value for the coefficient is 0.00, which is less than 0.05; therefore, the relationship between the two variables is statistically significant. As demonstrated by the estimated coefficient (B = 0.372), H1 is accepted.

Moderation-Analysis

Variables	***B***	$\mathbf{R^2}$	***P***
Adoption of Solar Energy ASE	0.291	0.171	***
Government Policies GP	0.201	0.081	***
ASE x GP	0.058	0.161	***

Note: Dependent Variable = Sustainable Environment Performance (SEP)

Explanation: The results in Table 3.5.2 show that ASE affected SEP < 0.01 (β = .291), so for R^2 = .171. Additionally, the GP has a positive impact on SEP (p < .01, β = .201), and (R^2 = .081). Thus, furthermore, the interaction effect (β = .058, p < .01) for the product of the two variables (ASE x GP) indicates that GP moderates the relationship between ASE and SEP. So, hypothesis H2 is accepted.

Discussion

With a focus on prioritizing the matter of adopting renewable energy, sustainability is a key lead for using as a compensation for the scarcity of conventional sources due to their participation in improvement related to the environment by reduction in costs, which provides the efficient impacts by adopting renewable energy sources for the sustainable development (Said et al.,2022). The most promising source of energy for future needs in developing nations is solar energy. Additionally, solar energy creates more jobs, lowers pollution, and benefits the environment (Kabir et al., 2018). For this reason, in the public mind, climate change is becoming a common environmental problem in the current age, and using solar energy can help reduce the impact of greenhouse gas emissions on the environment. In light of this occurrence, the government should take the necessary precautions, develop policies to promote renewable energy generation, and implement measures to protect the environment (Fayaz et al., 2022). With the addition of a developing country, the adoption of renewable energy technologies has played a significant role in increasing employment options for the public by improving social sustainability and promoting sustainable economic growth (Arroyo and Miguel et al., 2020). Renewable energy adoption is also popular for its role in environmental sustainability. It also reduces pollution and improves network efficiency (Franzitta et al., 2013). Continuous use of renewable energy technologies can reduce carbon dioxide emissions, making general citizens aware of the impacts of climate change (Kumar et al., 2020). A nation's government can significantly influence the adoption of alternative energy sources through financial subsidies, the provision of essential information, marketing policies, technical assistance, consultation services, and mentoring and strategy formulation for its organizations (Kata et al., 2022). Yang and Danwana et al. (2021) assessed that the government is accountable for formulating various policies to promote the adoption of renewable energy sources, which include the feed-in tariffs and the net metering policies, along with energy accounting procedures, which are deemed efficient strategies to encourage the utilization of photovoltaic (PV) systems. Cunningham and Eck et al. (2021) note that governmental policies encompass legislation, allocated loans, certain grants, and programs aimed at energy efficiency, alongside sustained research on the adoption of RES (Sandri et al., 2020). As discussed, both hypotheses are accepted.

Conclusion

To achieve sustainable environmental success, the adoption of solar energy plays an important role in supporting sustainable development alongside government policies. In terms of organization, adopting solar energy can increase productivity and efficiency. This theory contributes to the resource-based view theory to gain a competitive advantage. Additionally, adopting solar energy companies will give them a competitive edge in meeting company-wide sustainability goals. This study shows that solar energy has a positive impact on environmental sustainability. Furthermore, the government policies have a positive impact on the adoption of solar energy and sustainable environmental performance.

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